

(12) **United States Patent**  
**Ha et al.**

(10) **Patent No.:** **US 9,236,319 B2**  
(45) **Date of Patent:** **Jan. 12, 2016**

(54) **STACKED INTEGRATED CIRCUIT PACKAGE SYSTEM**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 843 days.

(21) Appl. No.: **12/056,402**

(22) Filed: **Mar. 27, 2008**

(65) **Prior Publication Data**

US 2009/0243072 A1 Oct. 1, 2009

(51) **Int. Cl.**  
**H01L 23/02** (2006.01)  
**H01L 23/31** (2006.01)  
**H01L 25/03** (2006.01)  
**H01L 25/065** (2006.01)  
**H01L 25/10** (2006.01)  
**H01L 23/00** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01L 23/3128** (2013.01); **H01L 25/03** (2013.01); **H01L 25/0657** (2013.01); **H01L 25/105** (2013.01); **H01L 24/48** (2013.01); **H01L 2224/16225** (2013.01); **H01L 2224/32145** (2013.01); **H01L 2224/32225** (2013.01); **H01L 2224/48225** (2013.01); **H01L 2224/48227** (2013.01); **H01L 2224/73204** (2013.01); **H01L 2224/73253** (2013.01); **H01L 2224/73265** (2013.01); **H01L 2225/0651** (2013.01); **H01L 2225/06568** (2013.01); **H01L 2225/107** (2013.01); **H01L 2225/1023** (2013.01); **H01L 2225/1058** (2013.01); **H01L 2924/15311**

(2013.01); **H01L 2924/15321** (2013.01); **H01L 2924/15331** (2013.01); **H01L 2924/1815** (2013.01); **H01L 2924/19041** (2013.01); **H01L 2924/19107** (2013.01)

(58) **Field of Classification Search**

CPC ..... **H01L 25/105**  
USPC ..... **257/686, E23.169**  
See application file for complete search history.

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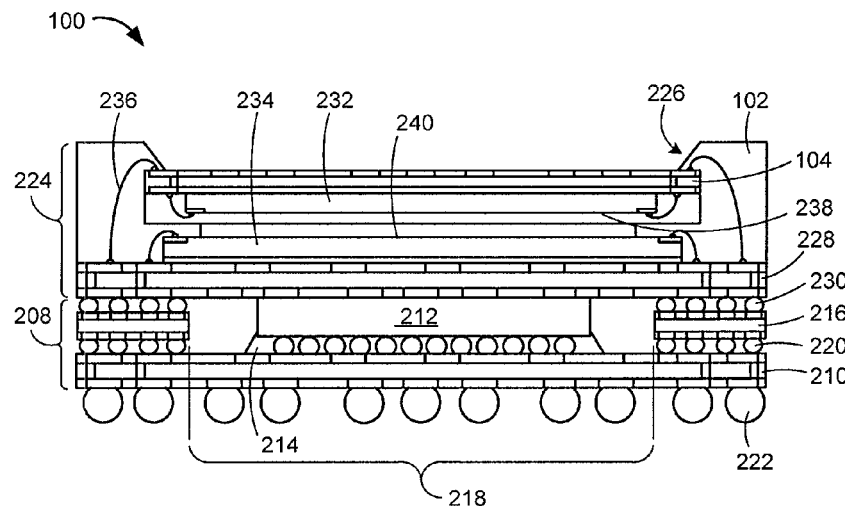
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(57) **ABSTRACT**

A stacked integrated circuit package system includes: providing a base integrated circuit package, and mounting a top integrated circuit package having a top interposer and a top encapsulation with a cavity therein or the cavity as a space between top intra-stack interconnects and the top interposer, with the top interposer exposed by the cavity, over the base integrated circuit package.

**16 Claims, 5 Drawing Sheets**



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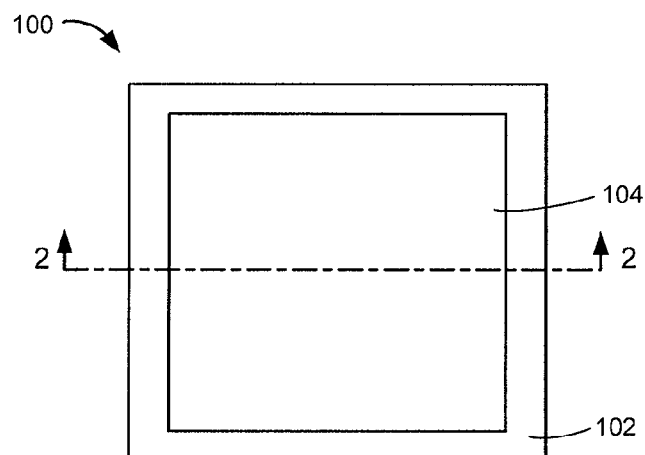


FIG. 1

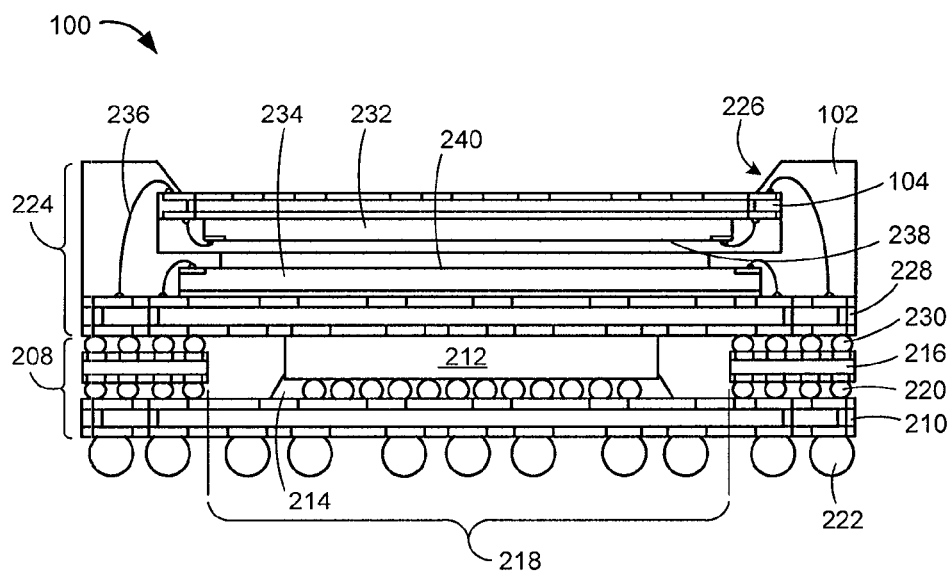


FIG. 2

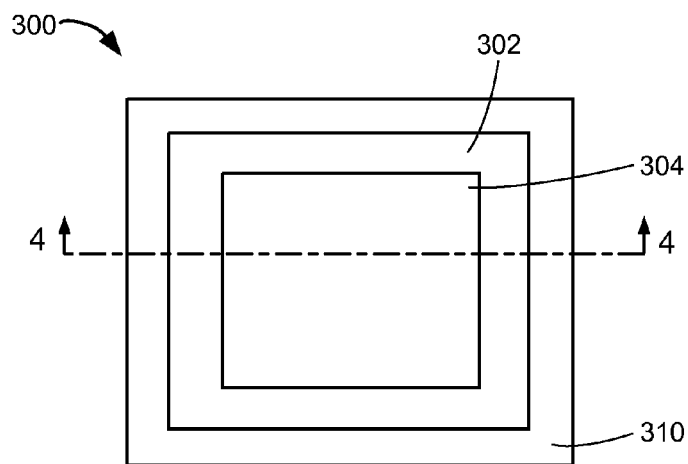


FIG. 3

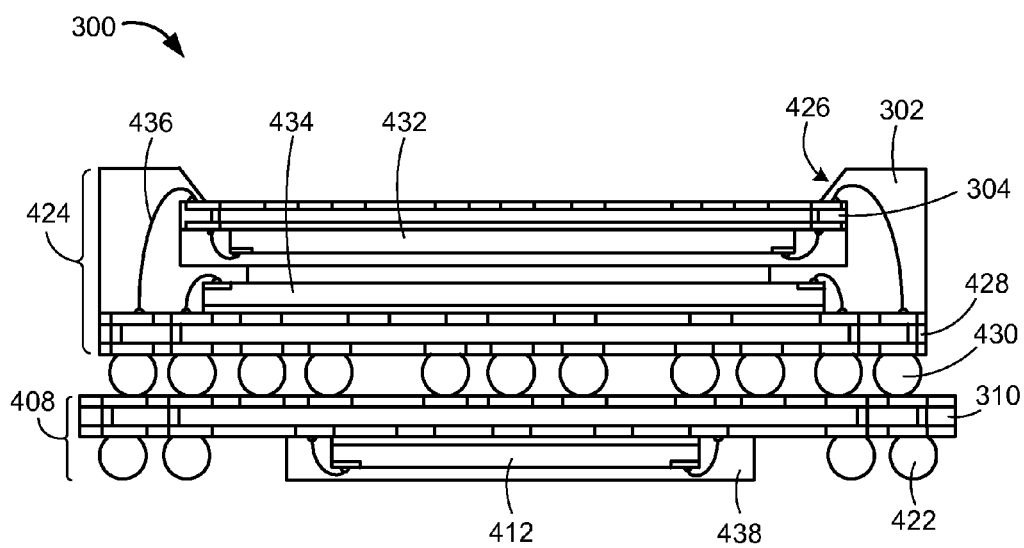


FIG. 4

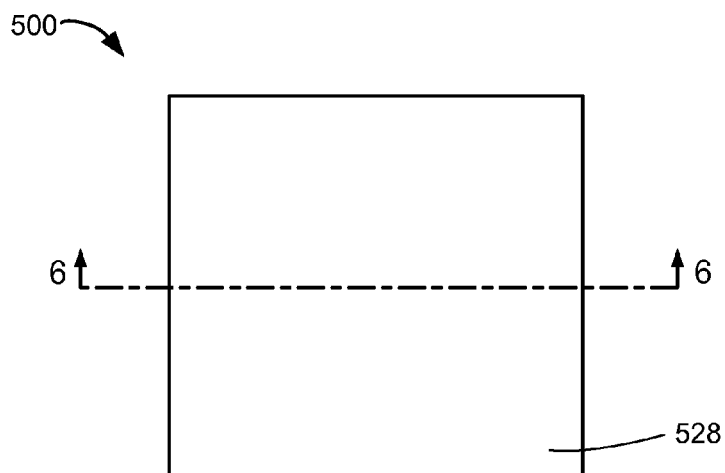


FIG. 5

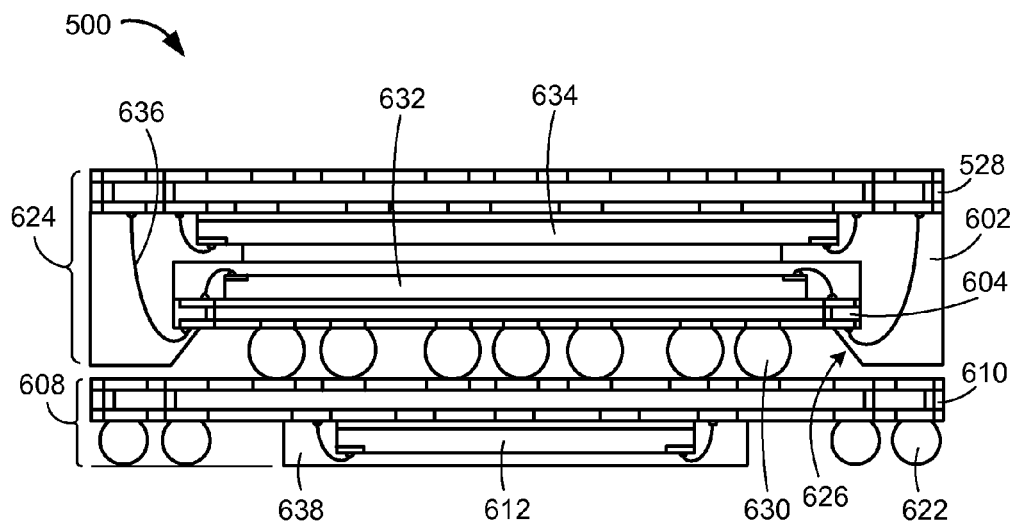


FIG. 6

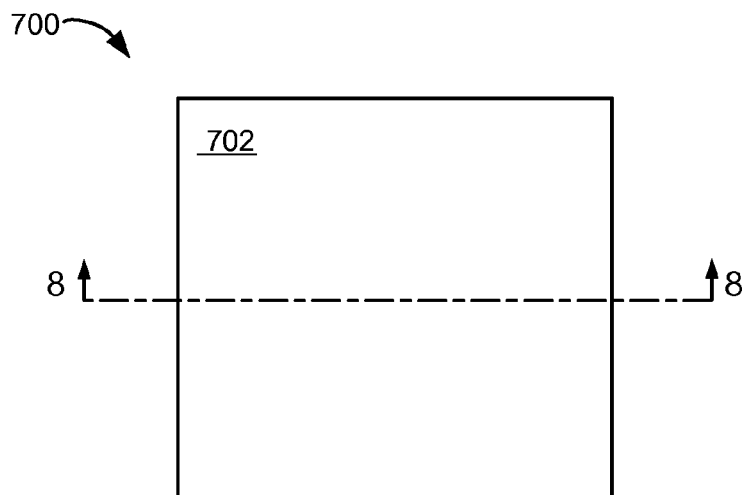


FIG. 7

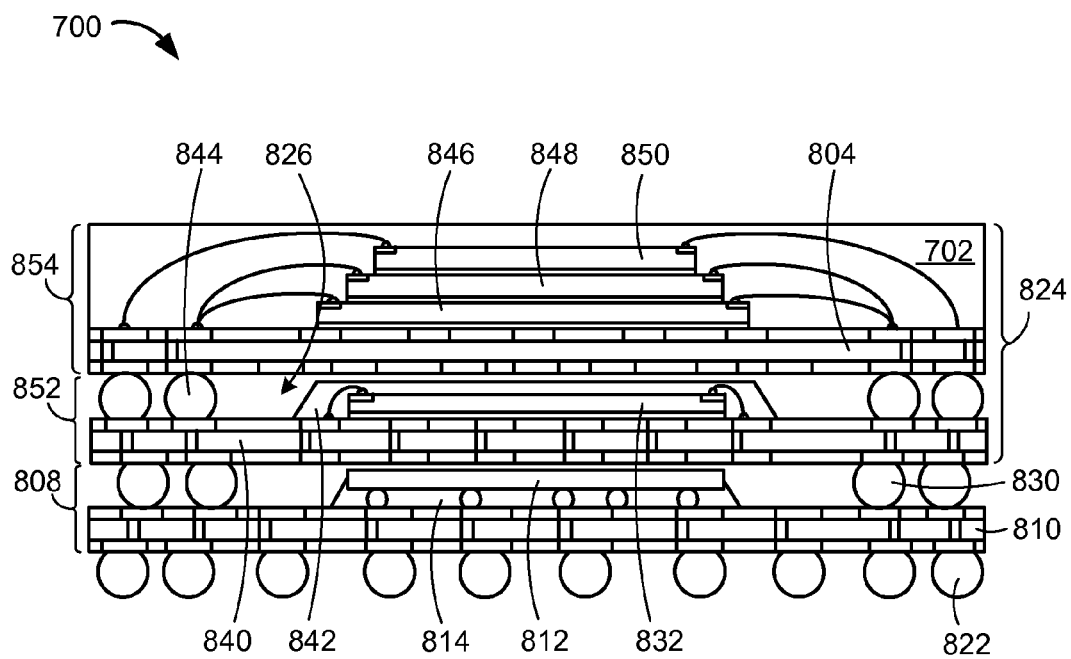


FIG. 8

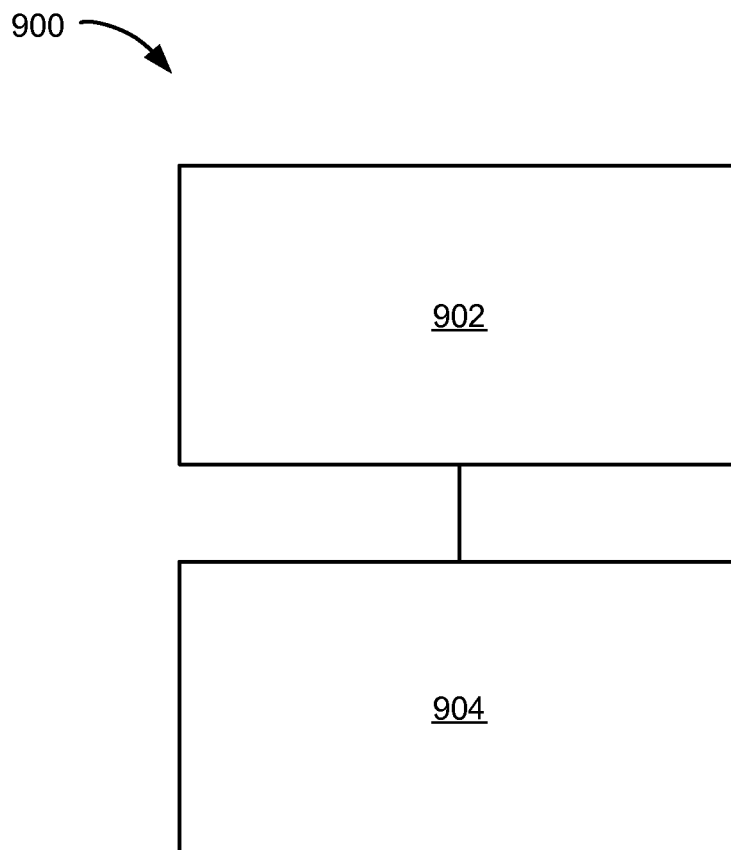


FIG. 9

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## STACKED INTEGRATED CIRCUIT PACKAGE SYSTEM

### CROSS-REFERENCE TO RELATED APPLICATION

The present application contains subject matter also related to concurrently filed U.S. patent application Ser. No. 12/056,418, now U.S. Pat. No. 7,750,454. The related application is assigned to STATS ChipPAC Ltd. and the subject matter thereof is incorporated herein by reference thereto.

The present application also contains subject matter related to U.S. patent application Ser. No. 12/040,558 filed Feb. 29, 2008, now U.S. Pat. No. 8,685,792. The related application is assigned to STATS ChipPAC Ltd. and the subject matter thereof is incorporated herein by reference thereto.

### TECHNICAL FIELD

The present invention relates generally to an integrated circuit package system, and more particularly to a system with a stacked integrated circuit package system.

### BACKGROUND ART

Electronic devices such as smart phones, personal digital assistants, location based devices, digital cameras, music players, computers, or transportation, have become an integral part of many daily activities. Key components of these electronic devices are integrated circuit devices. These tiny integrated circuits must perform during daily activities including a wide variety of environmental conditions as well as potentially damaging forces. Many and varied types of packaging, intended for protection, interconnection or mounting, have been developed for integrated circuit devices.

Integrated circuit dies are conventionally enclosed in plastic packages that provide protection from hostile environments and enable electrical interconnection between the integrated circuit die and an underlying substrate such as a printed circuit board (PCB). The elements of such a package include: a lead frame or substrate, an integrated circuit die, bonding material to attach the integrated circuit die to the lead frame or substrate, bond wires or other connectors that electrically connect pads on the integrated circuit die to the lead frame or substrate. The package can also include a plastic or other insulating material that covers the components and forms the exterior of the package.

Wafer manufacturing strives to reduce transistor or capacitor feature size in order to increase circuit density and enhance functionality. Device geometries with sub-micron line widths are so common that individual chips routinely contain millions of electronic devices. Reduced feature size has been quite successful in improving electronic systems, and continuous development is expected in the future. However, significant obstacles to further reduction in feature size are being encountered. These obstacles include defect density control, optical system resolution limits, and availability of processing material and equipment. Attention has therefore increasingly shifted to semiconductor packaging as a means to fulfill the relentless demands for enhanced system performance.

Drawbacks of conventional designs include a relatively large footprint of the package on the mounting surface of motherboard. The footprint reflects dimensions that are typically the maximum of the package, namely, the maximum x-y dimensions of the package. In applications where mounting space is at a premium, such as pagers, portable telephones,

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and personal computers, among others, a large footprint is undesirable. With the goal of increasing the amount of circuitry in a package, but without increasing the area of the package so that the package does not take up any more space on the circuit board, manufacturers have been stacking two or more die within a single package. Unfortunately, sufficient overlap for electrical interconnect, large footprint top packages, increased device integration, pre-testing, and interconnect lengths have plagued previous package designs.

Thus, a need still remains for a stacked integrated circuit package system to improve area and volume. In view of the ever-increasing commercial competitive pressures, along with growing consumer expectations and the diminishing opportunities for meaningful product differentiation in the marketplace, it is critical that answers be found for these problems. Additionally, the need to save costs, improve efficiencies and performance, and meet competitive pressures, adds an even greater urgency to the critical necessity for finding answers to these problems.

Solutions to these problems have been long sought but prior developments have not taught or suggested any solutions and, thus, solutions to these problems have long eluded those skilled in the art.

### DISCLOSURE OF THE INVENTION

The present invention provides a stacked integrated circuit package system including a base integrated circuit package, and mounting a top integrated circuit package having a top interposer and a top encapsulation with a cavity therein or the cavity as a space between top intra-stack interconnects and the top interposer, with the top interposer exposed by the cavity, over the base integrated circuit package.

Certain embodiments of the invention have other aspects in addition to or in place of those mentioned above. The aspects will become apparent to those skilled in the art from a reading of the following detailed description when taken with reference to the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of a stacked integrated circuit package system in a first embodiment of the present invention;

FIG. 2 is a cross-sectional view of the stacked integrated circuit package system along line 2-2 of FIG. 1;

FIG. 3 is a top view of a stacked integrated circuit package system in a second embodiment of the present invention;

FIG. 4 is a cross-sectional view of the stacked integrated circuit package system along line 4-4 of FIG. 3;

FIG. 5 is a top view of a stacked integrated circuit package system in a third embodiment of the present invention;

FIG. 6 is a cross-sectional view of the stacked integrated circuit package system along line 6-6 of FIG. 5;

FIG. 7 is a top view of a stacked integrated circuit package system in a fourth embodiment of the present invention;

FIG. 8 is a cross-sectional view of the stacked integrated circuit package system along line 8-8 of FIG. 7; and

FIG. 9 is a flow chart of a stacked integrated circuit package system for manufacturing of the stacked integrated circuit package system in an embodiment of the present invention.

### BEST MODE FOR CARRYING OUT THE INVENTION

The following embodiments are described in sufficient detail to enable those skilled in the art to make and use the invention. It is to be understood that other embodiments



would be evident based on the present disclosure, and that system, process, or mechanical changes may be made without departing from the scope of the present invention.

In the following description, numerous specific details are given to provide a thorough understanding of the invention. However, it will be apparent that the invention may be practiced without these specific details. In order to avoid obscuring the present invention, some well-known circuits, system configurations, and process steps are not disclosed in detail. Likewise, the drawings showing embodiments of the system are semi-diagrammatic and not to scale and, particularly, some of the dimensions are for the clarity of presentation and are shown greatly exaggerated in the drawing FIGS. Generally, the invention can be operated in any orientation.

In addition, where multiple embodiments are disclosed and described having some features in common, for clarity and ease of illustration, description, and comprehension thereof, similar and like features from one to another will ordinarily be described with like reference numerals. The embodiments have been numbered first embodiment, second embodiment, etc. as a matter of descriptive convenience and are not intended to have any other significance or provide limitations for the present invention.

For expository purposes, the term “horizontal” as used herein is defined as a plane parallel to the plane or surface of the integrated circuit, regardless of its orientation. The term “vertical” refers to a direction perpendicular to the horizontal as just defined. Terms, such as “above”, “below”, “bottom”, “top”, “side” (as in “sidewall”), “higher”, “lower”, “upper”, “over”, and “under”, are defined with respect to the horizontal plane. The term “on” means there is direct contact among elements. The term “processing” as used herein includes deposition of material, patterning, exposure, development, etching, cleaning, molding, and/or removal of the material or as required in forming a described structure. The term “system” as used herein means and refers to the method and to the apparatus of the present invention in accordance with the context in which the term is used.

Referring now to FIG. 1, therein is shown a top view of a stacked integrated circuit package system 100 in a first embodiment of the present invention. The top view depicts a top encapsulation 102, such as a cover including an epoxy molding compound. A top interposer 104, such as a laminated substrate, can be exposed by the top encapsulation 102.

Referring now to FIG. 2, therein is shown a cross-sectional view of the stacked integrated circuit package system 100 along line 2-2 of FIG. 1. The cross-sectional view depicts a base integrated circuit package 208. The base integrated circuit package 208 can include a base package carrier 210, such as a laminated substrate and a first base integrated circuit device 212 such as a flip chip, an encapsulated integrated circuit, a wire bonded chip, or a packaged integrated circuit. The first base integrated circuit device 212 can be mounted over and on the base package carrier 210. Optionally, the base integrated circuit package 208 can include a base underfill 214, such as an epoxy molding compound, under the first base integrated circuit device 212.

The base integrated circuit package 208 can include additional integrated circuit devices, such as one or more flip chips, wire bonded chips, or packaged integrated circuits. The base integrated circuit package 208 may be or may include a Known Good Package (“KGP”) that has been functionally tested.

A base interposer 216 can be mounted over the base package carrier 210. For example, the base interposer 216, such as a laminated substrate having a central aperture 218, can be mounted over the base package carrier 210 with the first base

integrated circuit device 212 within the central aperture 218 of the base interposer 216. A base interposer interconnect 220, such as a solder ball, can be used to couple the base interposer 216 with the base package carrier 210.

A base external interconnect 222, such as a solder ball, can attach to the stacked integrated circuit package system 100 for connection to the next system level (not shown), such as a printed circuit board or another integrated circuit package system. In this example, the base external interconnect 222 is attached below and to the base package carrier 210.

A top integrated circuit package 224 can be mounted over the base integrated circuit package 208. The top encapsulation 102 of the top integrated circuit package 224 includes a recess 226 which exposes the top interposer 104. The top integrated circuit package 224 can include a top package carrier 228, such as a substrate. In this example, the recess 226 is over the top package carrier 228.

A base intra-stack interconnect 230, such as a solder ball, can form an interconnection between the base integrated circuit package 208 and the top integrated circuit package 224. Other examples of the base intra-stack interconnect 230 include column grid arrays, pin interconnects, post interconnects, interconnects formed using folded printed circuit boards (PCBs) or combinations thereof. In this example, the base intra-stack interconnect 230 is mounted on and over a top surface of the base interposer 216 and couples the base integrated circuit package 208 to the top integrated circuit package 224 through a bottom surface of the top package carrier 228. The bottom surface of the top package carrier 228 is in direct contact with the first base integrated circuit device 212.

The top integrated circuit package 224 can include a first top integrated circuit device 232 such as an integrated circuit die, a flip chip, a wire bonded chip, or a packaged integrated circuit. The first top integrated circuit device 232 can be below the top interposer 104 and can be mounted on a bottom side of the top interposer 104 opposite the recess 226. The top package carrier 228 can be below the top interposer 104 and be in contact with the top encapsulation 102. The top integrated circuit package 224 can include additional integrated circuit devices, such as integrated circuit dice, flip chips, wire bonded chips, or packaged integrated circuits. For example, a second top integrated circuit device 234, such as an integrated circuit die, can be mounted on or over a top side of the top package carrier 228 with the top side of the top package carrier 228 facing the bottom side of the top interposer 104.

The top integrated circuit package 224 may be or may include a Known Good Package (“KGP”). For example, the first top integrated circuit device 232, additional integrated circuit devices such as the second top integrated circuit device 234 or any combination thereof may be tested before or after the top encapsulation 102 is formed. Furthermore, the top integrated circuit package 224 may be functionally tested before mounting the top integrated circuit package 224 over the base integrated circuit package 208. This feature can further reduce manufacturing cost, increase yield, and increase reliability.

The top package carrier 228 can be electrically coupled to the top interposer 104 with a top internal interconnect 236 such as a wire, wire-bond wire or wire bond ribbon. Other examples of the top internal interconnect 236 include solder balls, column grid arrays, pin interconnects, post interconnects, interconnects formed using folded printed circuit boards (PCBs) or combinations thereof.

It has been discovered that some embodiments of the present invention, such as the stacked integrated circuit package system 100, can provide a stacked integrated circuit pack-

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age system with reduced profile. For example, the stacked integrated circuit package system **100** includes the top interposer **104** and disposed in the recess **226**. This configuration can provide connectivity of the stacked integrated circuit package system **100** to external systems with a reduced system height.

Although the base integrated circuit package **208** is illustrated with the first base integrated circuit device **212** mounted over the base package carrier **210**, it is understood that the base integrated circuit package **208** can include multichip packages, flip chip packages, lead frame base packages, board-on-chip (BOC) packages, system-on-a-package (SIP) packages, package-in-a-package (PiP) packages and any combination thereof.

For illustrative purposes, the stacked integrated circuit package system **100** is shown with the base package carrier **210** and the top package carrier **228** of the same dimensions. However, it is understood the base package carrier **210** and the top package carrier **228** can have different relative dimensions.

For illustrative purposes, the base interposer **216** is illustrated with the central aperture **218** with the first base integrated circuit device **212** within the central aperture **218** of the base interposer **216**. However, it is understood that in the stacked integrated circuit package system **100**, the first base integrated circuit device **212** may not be mounted within the central aperture **218** of the base interposer **216**.

Furthermore, it is understood that interposers without the central aperture **218** may be used in conjunction with the current invention. For example, in some embodiments, a solid or perforated interposer or an interposer formed from multiple pieces may be mounted over the base package carrier with the first base integrated circuit device mounted above or below the base interposer. Furthermore, the base integrated circuit package can include a base interposer that does not provide electrical interconnection.

Referring now to FIG. 3, therein is shown a top view of a stacked integrated circuit package system **300** in a second embodiment of the present invention. The top view depicts a top encapsulation **302**, such as a cover including an epoxy molding compound, and a base package carrier **310**, such as a laminated substrate. A top interposer **304**, such as a laminated substrate or interposer, can be exposed by the top encapsulation **302**.

Referring now to FIG. 4, therein is shown a cross-sectional view of the stacked integrated circuit package system **300** along line 4-4 of FIG. 3. The cross-sectional view depicts a base integrated circuit package **408** with the base package carrier **310**. The base integrated circuit package **408** can include a first base integrated circuit device **412** such as a flip chip, a wire bonded chip, or a packaged integrated circuit. The first base integrated circuit device **412** can be mounted under and to the base package carrier **310**. The base integrated circuit package **408** can include a base encapsulation **438**, such as a cover including an epoxy molding compound.

The base integrated circuit package **408** can include additional integrated circuit devices such one or more flip chips, wire bonded chips, or packaged integrated circuits. The base integrated circuit package **408** may be or may include a Known Good Package ("KGP") that has been functionally tested.

A base external interconnect **422**, such as a solder ball, can attach to the stacked integrated circuit package system **300** for connection to the next system level (not shown), such as a printed circuit board or another integrated circuit package system. In this example, the base external interconnect **422** is attached below and to the base package carrier **310**.

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A top integrated circuit package **424** is mounted over the base integrated circuit package **408**. The top encapsulation **302** of the top integrated circuit package **424** includes a recess **426** which exposes the top interposer **304**. The top integrated circuit package **424** can include a top package carrier **428**. In this example, the recess **426** is over the top package carrier **428**.

A base intra-stack interconnect **430**, such as a solder ball, can form an interconnection between the base integrated circuit package **408** and the top integrated circuit package **424**. Other examples of the base intra-stack interconnect **430** include column grid arrays, pin interconnects, post interconnects, interconnects formed using folded printed circuit boards (PCBs) or combinations thereof. In this example, the base intra-stack interconnect **430** is mounted over the base package carrier **310** and couples the base integrated circuit package **408** to the top integrated circuit package **424** through the top package carrier **428**.

The top integrated circuit package **424** can include a first top integrated circuit device **432** such as one or more flip chips, wire bonded chips, or packaged integrated circuits. The first top integrated circuit device **432** can be under the top interposer **304**. The top integrated circuit package **424** can include additional integrated circuit devices such as flip chips, wire bonded chips, or packaged integrated circuits. For example, a second top integrated circuit device **434** can be mounted over the top package carrier **428**.

The top integrated circuit package **424** may be or may include a Known Good Package ("KGP"). For example, the first top integrated circuit device **432**, additional integrated circuit devices such as the second top integrated circuit device **434** or any combination thereof may be tested before or after the top encapsulation **302** is formed. Furthermore, the top integrated circuit package **424** may be functionally tested before mounting the top integrated circuit package **424** over the base integrated circuit package **408**. This feature can further reduce manufacturing cost and increase reliability.

The top package carrier **428** can be electrically coupled to the top interposer **304** with a top internal interconnect **436** such as a wire, wire-bond wire or wire bond ribbon. Other examples of the top internal interconnect **436** include solder balls, column grid arrays, pin interconnects, post interconnects, interconnects formed using folded printed circuit boards (PCBs) or combinations thereof.

Although the base integrated circuit package **408** is illustrated with one integrated circuit device (base integrated circuit device **412**) mounted under the base package carrier **310**, it is understood that the base integrated circuit package **408** can include multichip packages, flip chip packages, lead frame base packages, board-on-chip (BOC) packages, system-on-a-package (SIP) packages, package-in-a-package (PiP) packages and any combination thereof.

Referring now to FIG. 5, therein is shown a top view of a stacked integrated circuit package system **500** in a third embodiment of the present invention. The top view depicts a top package carrier **528**, such as a laminated substrate, a top external interconnect **506**.

Referring now to FIG. 6, therein is shown a cross-sectional view of the stacked integrated circuit package system **500** along line 6-6 of FIG. 5. The cross-sectional view depicts a base integrated circuit package **608**. The base integrated circuit package **608** can include a base package carrier **610** and a first base integrated circuit device **612**, such as a flip chip, a wire bonded chip, or a packaged integrated circuit. The first base integrated circuit device **612** can be mounted under the base package carrier **610**. The base integrated circuit package

**608** can include a base encapsulation **638**, such as a cover including an epoxy molding compound.

The base integrated circuit package **608** can include additional integrated circuit devices such one or more flip chips, wire bonded chips, or packaged integrated circuits. The base integrated circuit package **608** may be or may include a Known Good Package (“KGP”) that has been functionally tested.

The base package carrier **610** may include other structures (not shown), such as metal traces, metal layers, insulating layers, electrical vias, landing pads, or a combination thereof. A base external interconnect **622**, such as a solder ball, can attach to the stacked integrated circuit package system **500** for connection to the next system level (not shown), such as a printed circuit board or another integrated circuit package system. In this example, the base external interconnect **622** is attached below and to the base package carrier **610**.

A top integrated circuit package **624** is mounted over the base integrated circuit package **608**. A top encapsulation **602**, such as a cover including an epoxy molding compound, of the top integrated circuit package **624** includes a recess **626** which exposes a top interposer **604**, such as a laminated substrate. The top integrated circuit package **624** can include the top package carrier **528**. In this example, the recess **626** is below the top package carrier **528**. This configuration may be referred to as an “upside down” or “inverted” package-on-package (POP) system.

A base intra-stack interconnect **630**, such as a solder ball, can form an interconnection between the base integrated circuit package **608** and the top integrated circuit package **624**. Other examples of the base intra-stack interconnect **630** include column grid arrays, pin interconnects, post interconnects, interconnects formed using folded printed circuit boards (PCBs) or combinations thereof. In this example, the base intra-stack interconnect **630** is mounted over the base package carrier **610** and couples the base integrated circuit package **608** to the top integrated circuit package **624** through the top interposer **604**.

It has been discovered that some embodiments of the present invention, such as the stacked integrated circuit package system **500**, can provide a stacked integrated circuit package system with reduced profile. For example, the stacked integrated circuit package system **500** includes the base intra-stack interconnect **630**, such as a solder ball, formed below the top interposer **604** and disposed in the recess **626**. This configuration can provide the functionality of internal system interconnection with a reduced system height.

The top integrated circuit package **624** can include a first top integrated circuit device **632** such as one or more flip chips, wire bonded chips, or packaged integrated circuits. The first top integrated circuit device **632** can be over the top interposer **604**. The top integrated circuit package **624** can include additional integrated circuit devices such as flip chips, wire bonded chips, or packaged integrated circuits. For example, a second top integrated circuit device **634**, such as an integrated circuit die, can be mounted under the top package carrier **528**.

The top integrated circuit package **624** may be or may include a Known Good Package (“KGP”). For example, the first top integrated circuit device **632**, additional integrated circuit devices such as the second top integrated circuit device **634** or any combination thereof may be tested before or after the top encapsulation **602** is formed. Furthermore, the top integrated circuit package **624** may be functionally tested before mounting the top integrated circuit package **624** over

the base integrated circuit package **608**. This feature can further reduce manufacturing cost, increase yield, and increase reliability.

The top package carrier **528** can be electrically coupled to the top interposer **604** with a top internal interconnect **636** such as a wire, wire-bond wire or wire bond ribbon. Other examples of the top internal interconnect **636** include solder balls, column grid arrays, pin interconnects, post interconnects, interconnects formed using folded printed circuit boards (PCBs) or combinations thereof.

The top external interconnect **506**, such as a solder ball, can attach to the stacked integrated circuit package system **500** for connection to the next system level (not shown), such as a printed circuit board or another integrated circuit package system. In this example, the top external interconnect **506** is attached over and to the top package carrier **528**.

Although the base integrated circuit package **608** is illustrated with the first base integrated circuit device **612** mounted under the base package carrier **610**, it is understood that the base integrated circuit package **608** can include multichip packages, flip chip packages, lead frame base packages, board-on-chip (BOC) packages, system-on-a-package (SIP) packages, package-in-a-package (PiP) packages and any combination thereof.

Referring now to FIG. 7, therein is shown a top view of a stacked integrated circuit package system **700** in a fourth embodiment of the present invention. The top view depicts a top package encapsulation **702**, such as a cover including an epoxy molding compound.

Referring now to FIG. 8, therein is shown a cross-sectional view of the stacked integrated circuit package system **700** along line 8-8 of FIG. 7. The cross-sectional view depicts a base integrated circuit package **808**. The base integrated circuit package **808** includes a first base integrated circuit device **812** such as a flip chip, a wire bonded chip, or a packaged integrated circuit. The first base integrated circuit device **812** can be mounted over a base package carrier **810**, such as a laminated substrate. The base integrated circuit package **808** can include a base underfill **814**, such as an epoxy molding compound, under the first base integrated circuit device **812**.

The base integrated circuit package **808** can include additional integrated circuit devices such one or more flip chips, wire bonded chips, or packaged integrated circuits. The base integrated circuit package **808** may be or may include a Known Good Package (“KGP”) that has been functionally tested.

A base external interconnect **822**, such as a solder ball, can attach to the stacked integrated circuit package system **700** for connection to the next system level (not shown), such as a printed circuit board or another integrated circuit package system. In this example, the base external interconnect **822** is attached below and to the base package carrier **810**.

A top integrated circuit package **824** is mounted over the base integrated circuit package **808**. The top integrated circuit package **824** of the top integrated circuit package **824** includes a first top integrated circuit device **832** such as one or more flip chips, wire bonded chips, or packaged integrated circuits. The first top integrated circuit device **832** can be mounted over an intermediate package carrier **840**, such as a laminated substrate. The intermediate package carrier is optional.

An encapsulant protrusion **842**, such as a cover including an epoxy molding compound, can be formed over the first top integrated circuit device **832**. The top integrated circuit package **824** can include additional integrated circuit devices such as flip chips, wire bonded chips, or packaged integrated circuits. In this example, base intra-stack interconnects **830**,

such as solder balls, are mounted over the base package carrier **810** and couple the base integrated circuit package **808** to the top integrated circuit package **824** through the intermediate package carrier **840**.

The top integrated circuit package **824** includes a top interposer **804**, such as a laminated substrate. Top intra-stack interconnects **844** are single conductive structures such as solder balls which are not formed from different processes or materials. The top intra-stack interconnects **844** can form an electrical interconnection between the intermediate package carrier **840** and the top interposer **804**. Other examples of the top intra-stack interconnects **844** include column grid arrays, pin interconnects and post interconnects.

It has been discovered that some embodiments of the present invention, such as the stacked integrated circuit package system **700**, can provide a stacked integrated circuit package system with reduced profile. For example, the stacked integrated circuit package system **700** includes top intra-stack interconnects which are single conductive structures, not formed from different processes or materials. Single conductive structures can provide reduced profile interconnects compared to some compound structures, such as pillar and solder ball intra-stack interconnects. Using single conductive structures for at least some of the intra-stack interconnects, such as the top intra-stack interconnects, can provide the functionality of internal system interconnection with a reduced system height.

In this example, the encapsulant protrusion **842** is over the intermediate package carrier **840**. A cavity **826** is formed as the space between the top intra-stack interconnects **844** and the top interposer **804** with the top interposer **804** exposed by the cavity **826**.

A first mounting integrated circuit device **846**, such as a flip chip, a wire bonded chip, or a packaged integrated circuit, can be mounted over the top interposer **804**. The additional integrated circuit devices such as flip chips, wire bonded chips, or packaged integrated circuits can be mounted over the top interposer **804**. For example, a second mounting integrated circuit device **848**, such as an integrated circuit die, and a third mounting integrated circuit device **850**, such as an integrated circuit die, can be mounted over the top interposer **804**. In this example, the top package encapsulation **702** is formed over the top interposer **804**.

Portions of the stacked integrated circuit package system **700** can be pre-assembled and then mounted to form the stacked integrated circuit package system **700**. For example, an intermediate integrated circuit package **852** including the intermediate package carrier **840** and the encapsulant protrusion **842** thereover may be pre-assembled.

In this example, the first top integrated circuit device **832** can be mounted over the intermediate package carrier **840** and the encapsulant protrusion **842** can be formed over the first top integrated circuit device **832**. After pre-assembly, the intermediate integrated circuit package **852** can be mounted over the base integrated circuit package **808** or included in another assembly before mounting over the base integrated circuit package **808**.

A mounting integrated circuit package **854** including the top interposer **804** can be pre-assembled. For example, the first mounting integrated circuit device **846** as well as additional mounting integrated circuit devices, such as the second mounting integrated circuit device **848** and the third mounting integrated circuit device **850**, can be mounted over the top interposer **804**, forming the mounting integrated circuit package **854**. The top package encapsulation **702** can be formed over the top interposer **804** before or after the mounting integrated circuit package **854** is mounted over the interme-

mediate package carrier **840**. The mounting integrated circuit package **854** can be mounted over the intermediate package carrier **840** with the top intra-stack interconnects **844**, forming the cavity **826** as a space between the top intra-stack interconnects **844** and the top interposer **804**.

The base integrated circuit package **808**, the intermediate integrated circuit package **852** and the mounting integrated circuit package **854** may be pre-assembled in various orders. For example, the mounting integrated circuit package **854** can be mounted over the intermediate integrated circuit package **852** with the top intra-stack interconnects **844** before mounting the intermediate integrated circuit package **852** over the base integrated circuit package **808** with the base intra-stack interconnects **830**, forming the stacked integrated circuit package system **700**.

In another example, the intermediate integrated circuit package **852** can be assembled and mounted over the base integrated circuit package **808** before an assembly including the mounting integrated circuit package **854** is mounted over the intermediate integrated circuit package **852**, forming the cavity **826** as a space between the top intra-stack interconnects **844** and the top interposer **804**.

The base integrated circuit package **808**, the intermediate integrated circuit package **852** or the mounting integrated circuit package **854** or combinations thereof may be or may include a Known Good Package ("KGP"). Furthermore, the base integrated circuit package **808**, the intermediate integrated circuit package **852** or the mounting integrated circuit package **854** or combinations thereof may be functionally tested before the stacked integrated circuit package system **700** is fully assembled. This feature can further reduce manufacturing cost and increase reliability.

The stacked integrated circuit package system **700** is illustrated with the cavity **826** formed as the space between the top intra-stack interconnects **844** and the top interposer **804** with the top interposer **804** exposed by the cavity **826**. However, it is understood that the top interposer **804** may be partially exposed by the cavity **826**. For example, the region between the top interposer **804** and the encapsulant protrusion **842** may be partially or completely filled by the encapsulant protrusion **842** or another structure, such as a thermally conductive material or an epoxy, as long as some portion of the top interposer **804** remains exposed by the cavity **826** between the top intra-stack interconnects **844** and the top interposer **804**.

Although the base integrated circuit package **808** is illustrated with the first base integrated circuit device **812** mounted over the base package carrier **810**, it is understood that the base integrated circuit package **808** can include multichip packages, flip chip packages, lead frame base packages, board-on-chip (BOC) packages, system-on-a-package (SIP) packages, package-in-a-package (PiP) packages and any combination thereof.

It has been discovered that the present invention provides a compact stacked integrated circuit package system. The present invention can provide improved yields due to the modular nature of the system. The base integrated circuit package and the top integrated circuit package may be independently tested or characterized before assembly in a stacked integrated circuit package system according to the current invention.

It also has been discovered that the present invention provides a stacked integrated circuit package system with improved thermal management properties. For example, the gaps in the current invention such as the cavity can provide air flow channels for improved heat dissipation.

Yet an important aspect of the present invention is that the present invention can provide a system capable of complex

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internal interconnections. Some embodiments of the current invention include a base package carrier, a base interposer, a top package carrier and a top interposer including structures such as metal traces, metal layers, insulating layers, electrical vias, landing pads, or a combination thereof for providing complex interconnections. When implemented in conjunction with base intra-stack interconnects, base interposer interconnects and top internal interconnects, the present invention can enable the implementation of complex interconnected systems including two or more integrated circuit devices with a small footprint.

Referring now to FIG. 9 therein is shown a flow chart of a stacked integrated circuit package system 900 for manufacturing of the stacked integrated circuit package system 100 in an embodiment of the present invention. The system 900 includes providing a base integrated circuit package, in a block 902; and mounting a top integrated circuit package having a top interposer and a top encapsulation with a cavity therein or the cavity as a space between top intra-stack interconnects and the top interposer, with the top interposer exposed by the cavity, over the base integrated circuit package, in a block 904.

Yet another important aspect of the present invention is that it valuably supports and services the historical trend of reducing costs, simplifying systems, and increasing performance.

These and other valuable aspects of the present invention consequently further the state of the technology to at least the next level.

Thus, it has been discovered that the integrated circuit package system of the present invention furnishes important and heretofore unknown and unavailable solutions, capabilities, and functional aspects for improving yield, increasing reliability, and reducing cost of circuit system. The resulting processes and configurations are straightforward, cost-effective, uncomplicated, highly versatile, accurate, sensitive, and effective, and can be implemented by adapting known components for ready, efficient, and economical manufacturing, application, and utilization.

While the invention has been described in conjunction with a specific best mode, it is to be understood that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations that fall within the scope of the included claims. All matters hitherto set forth herein or shown in the accompanying drawings are to be interpreted in an illustrative and non-limiting sense.

What is claimed is:

1. A method of manufacture of a stacked integrated circuit package system comprising:
  - providing a base integrated circuit package including:
    - providing a base package carrier,
    - mounting a base interposer over the base package carrier, the base interposer having a central aperture,
    - forming a base intra-stack interconnect on a top surface of the base interposer,
    - forming a base interposer interconnect on a bottom surface of the base interposer, and
    - mounting a flip chip within the central aperture and on the base package carrier; and
  - mounting a top integrated circuit package on the base intra-stack interconnect and over the base interposer, the top integrated circuit package including:
    - a top interposer,
    - a top package carrier below the top interposer and with the base intra-stack interconnect on a bottom surface

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of the top package carrier and with the flip chip in direct contact with the bottom surface of the top package carrier, and

a top encapsulation on the top package carrier and the top interposer with a recess therein with the top interposer exposed by the recess.

2. The method as claimed in claim 1 wherein mounting the flip chip includes mounting the flip chip over the base package carrier.

3. The method as claimed in claim 1 wherein mounting a top integrated circuit package includes:
 

- mounting a first top integrated circuit device on the top interposer; and
- mounting a second top integrated circuit device on the top package carrier.

4. The method as claimed in claim 1 wherein mounting the top integrated circuit package having the top encapsulation with the recess therein and the top interposer exposed by the recess includes providing the top package carrier with the recess over the top package carrier.

5. The method as claimed in claim 1 further comprising forming a base external interconnect below the base integrated circuit package.

6. A method of manufacture of a stacked integrated circuit package system comprising:

- providing a base integrated circuit package including:
  - providing a base package carrier,
  - mounting a base interposer over the base package carrier, the base interposer having a central aperture,
  - forming a base intra-stack interconnect on a top surface of the base interposer,
  - forming a base interposer interconnect on a bottom surface of the base interposer, and
  - mounting a flip chip within the central aperture and on the base package carrier;

forming a base external interconnect below the base integrated circuit package; and

mounting a top integrated circuit package on the base intra-stack interconnect and over the base interposer, the top integrated circuit package including:

- a top interposer,
- a top package carrier below the top interposer and with the base intra-stack interconnect on a bottom surface of the top package carrier and with the flip chip in direct contact with the bottom surface of the top package carrier, and
- a top encapsulation on the top package carrier and the top interposer with a recess therein with the top interposer exposed by the recess.

7. The method as claimed in claim 6 wherein:
 

- forming the base intra-stack interconnect on the top surface of the base interposer includes coupling the base integrated circuit package to the top package carrier.

8. The method as claimed in claim 6 wherein the base interposer interconnect is used to couple the base package carrier and the base interposer.

9. A stacked integrated circuit package system comprising:
 

- a base integrated circuit package including:

- a base package carrier,
- a base interposer mounted over the base package carrier, the base interposer having a central aperture,
- a base intra-stack interconnect on a top surface of the base interposer,
- a base interposer interconnect on a bottom surface of the base interposer; and
- a flip chip mounted within the central aperture and on the base package carrier; and

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a top integrated circuit package mounted on the base intra-stack interconnect and over the base interposer, the top integrated circuit package including:

a top interposer,

a top package carrier below the top interposer and with the base intra-stack interconnect on a bottom surface of the top package carrier and with the flip chip in direct contact with the bottom surface of the top package carrier, and

a top encapsulation on the top package carrier and the top interposer with a recess therein with the top interposer exposed by the recess.

10. The system as claimed in claim 9 wherein the flip chip is mounted over the base package carrier.

11. The system as claimed in claim 9 wherein the top integrated circuit package includes:

a first top integrated circuit device mounted on the top interposer; and

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a second top integrated circuit device mounted on the top package carrier.

12. The system as claimed in claim 9 wherein the recess is over the top package carrier.

13. The system as claimed in claim 9 further comprising a base external interconnect formed below the base integrated circuit package.

14. The system as claimed in claim 9 further comprising a base underfill under the flip chip.

15. The system as claimed in claim 14 wherein the base intra-stack interconnect couples the base integrated circuit package to the top package carrier.

16. The system as claimed in claim 14 wherein the base interposer interconnect is used to couple the base package carrier and the base interposer.

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